3-F Induction Machine

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Abstract

This 3-F Induction Machine (3FIM) was designed, constructed, and evaluated its operating performance as an Arc welding machine, engine starter for stationary engines, and battery charger for storage batteries. Engineers, professors, trainers, assessors, and technicians from Welding, Automotive, and Mechanical served as the technical experts. Results revealed an excellent performance according to the set parameters by producing excitation or quiescent power and less energy consumption, conforming to the industry's standards. Furthermore, experts suggested making it lightweight for commercial use. Hence, the machine translates significant savings in large transformer applications such as industrial controls if used on a bigger scale.

Keywords: 3-F Induction machine, Arc welding, Big savings in extensive transformer application, excitation or quiescent power, Less energy consumption

1. Introduction

Today, the development of electrical machines for convenience is rapid—machines for automotive, fabrications shops, or even electrical following the trend. Especially in welding, engine boosters, or starters, battery chargers are powered by electricity for the user's convenience. Arc welding is defined by Sabhadiya (2020) as a "process used to join metal to metal by using electricity to generate enough heat to melt metal and the melted metals, when cooled, resulting in a joint of the metals. It is a type of welding that uses a welding power supply to create an arc between a metal stick ("electrode") and the base material to melt the metals at the point of contact. Arc welders can use either Direct Current (DC) or Alternating Current (AC) and consumable or non-consumable electrodes."

According to the Department of Science and Technology Metals Industry Research and Development Centre (DOST-MIRDC) (2016) on the Philippine Welding Fabrication Industry study, welding as "the fundamental vehicle of change, sophisticated technologies on welding and fabrication must intensively be adopted by local firms. Very few large companies cater to the industries that need a large volume of welded products and extensive welding services. Still, the industry cannot put a strong foothold on the manufacturing industry as it fails to provide a long-term solution to its needs with such limited technology. While expanding automation in the welding processes contributes to decreasing manufacturing costs and improving the quality of welded products, funding initiatives to fill the gap in the technological advancement of the domestic welding industry have not been addressed completely."

It is in this context that the researcher created the machine. The researcher applied a systems approach to address the ambiguities of state-of-the-art technologies in toroidal arc welding machines. Ahn Jeong No's (2010) technology provides a single-port multifunction arc welding apparatus. It has an interface that supplies electric power, gas, and welding wire to a torch that can be selectively performed. Also, it provides a multifunction arc welding apparatus having a single-port structure, which interfaces with power, gas, and electrode wires to be universal in supplying the torch from the main body of the arc welder. It is an object of the present invention to provide a multifunctional arc welding apparatus capable of simplifying the configuration of an interface for supplying a welding wire from the main body of an arc the welding machine to a torch and connecting the main body and the torch of the arc welding machine. Multifunction arc welding device provided a purpose but not as engine starter stationary engines and battery charger. However, Ni Minlu (2007) study, although energy-saving multifunction power supply, focused on separating the arc starting voltage and the operating voltage, superpose after rectification and form a combined external characteristic curve none on engine starter stationary engine and battery charger. Liu Jining's (2019) utility model related to a charging machine, in particular, to a simple structure, easy to use, capable of charging a battery pack, starting a car engine, and a multifunction charging and welding machine belongs to the technical field of chargers. However, the present study also has an additional feature: one of its outputs is a step-down transformer to provide a 110VAC source.

2. Synthesis

The unique feature of the 3FIM is that it utilises a locally available core, a toroidal core, and the winding in both primary and secondary are just correctly distributed in a single core. The single toroidal core accommodates the primary winding while the secondary winding is wound in the same core. However, it produces three main functions: arc welding, engine starter for stationary engines, and battery charging for storage batteries. It also has an extra feature: one of its outputs is a step-down transformer to provide a 110VAC source.

3. Research Significance

The research is significant to the welding and automotive industry. The 3FIM is multifunction welding, an easy-to-use machine that welds, charges batteries, and starts a stationary automobile for an extended period while maintaining its average temperature. Furthermore, the device is safe due to the protective casing made of non-conductive materials.

4. Purpose of the Research

Generally, this study aimed to design and construct a 3FIM. Specifically, this study aimed to design and build 3FIM and evaluate its performance concerning (1) resistance of the input and output winding; (2) insulation resistance of the input and output winding; (3) no load and with load primary current; (4)welding (secondary current AC); (5) engine starter (secondary current DC); (6) battery charger (Secondary current/charging current DC); (7) no load and with load primary voltage; (8)no secondary load voltage; (9) welding (secondary) voltage;

(10) engine starter (secondary) voltage; (11) battery charger (secondary) voltage; (12) winding temperature; and (13) power consumption.

5. Description of the Device

5.1 Design Criteria

5.1.1 ISO 17662:2005

The creation of the 3FIM met the requirements International Standard Organization (ISO) and the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardisation. (www.iso.org, 2005).

5.1.2. Normative references

The following referenced documents are indispensable for the creation of this machine (www.iso.org, 2005):

(1) EN 562, Gas welding equipment — Pressure gauges used in welding, cutting and allied processes;

(2) EN 729-1, Quality requirements for welding — Fusion welding of metallic materials — Part 1: Guidelines for selection and use;

(3) EN 729-2, Quality requirements for welding — Fusion welding of metallic materials — Part 2: Comprehensive quality requirements;

(4) EN 729-3, Quality requirements for welding — Fusion welding of metallic materials — Part 3: Standard quality requirements;

(5) EN 729-4, Quality requirements for welding — Fusion welding of metallic materials — Part 4: Elementary quality requirements;

(6) EN 970, Non-destructive examination of fusion welds — Visual examination;

(7) EN 1321, Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds;

(8) CR 12361, Destructive tests on welds in metallic materials — Etchants for macroscopic and microscopic examination;

(9) EN 13134, Brazing — Procedure approval;

(10) ENV 50184, Validation of arc welding equipment;

(11) EN ISO 14554-1, Quality requirements for welding — Resistance welding of metallic materials — Part 1: Comprehensive quality requirements (ISO 14554-1:2000);

(12) EN ISO 14554-2, Quality requirements for welding — Resistance welding of metallic materials — Part 2: Elementary quality requirements (ISO 14554-2:2000)

(13) EN ISO 14555, Welding — Arc stud welding of metallic materials (ISO 14555:1998)

(14) EN ISO 14744-5, Welding — Acceptance inspection of electron beam welding machines — Part 5: Measurement of run-out accuracy (ISO 14744-5:2000)

(15) EN ISO 15609-1, Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding (ISO 15609-1:2004)

(16) EN ISO 15609-2, Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2: Gas welding (ISO 15609-2:2001)

(17) EN ISO 15609-3, Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 3: Electron beam welding (ISO 15609-3:2004)

(18) EN ISO 15609-4, Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 4: Laser beam welding (ISO 15609-4:2004)

(19) EN ISO 15609-5, Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 5: Resistance welding (ISO 15609-5:2004)

(20) EN ISO 15620, Welding — Friction welding of metallic materials (ISO 15620:2000)

ISO 669, Resistance welding — Resistance welding equipment — Mechanical and electrical requirements

5.1.2 Battery Charging Standards

For a welding machine that acts as a battery charger, the researchers referred to CSA C812 on large battery charger systems (Engineering 360: 2016). This standard specifies the test method for measuring and reporting the energy performance of large battery charger systems. Note: This standard is technology-neutral. This standard applies to large battery charger systems such as forklifts, automobiles, electric personnel, etc. The engine starter (with load) secondary current ranges up to 300 amperes. The machine can also be used as a charger for storage batteries with a primary current (no load) current of 0.02 amperes to 5amperes maximum charging current. The battery charger (with load) secondary current ranges up to 35amperes.

5.1.3 Starter Motor Application Considerations

In developing the 3FIM, incorporating engine start for stationary automobiles conforms with the SAE Recommended Practice (SAE, 1997) and identifies some primary and general conditions when making electrical starter motor applications. The present invention utilised primary current (no load) Current of 0.02 amperes to 20 amperes maximum engine starter current for automobiles.

5.2 Limitations and Constraints

The 3FIM is limited to utilising a locally available core, a toroidal core, and both primary and secondary winding are correctly distributed in a single core. The single toroidal core accommodates the primary winding while the secondary winding is wound in the same core. Moreover, the machine is limited to three main functions: arc welding, engine starter for stationary engines, and battery charging for storage batteries. It also has an extra feature: one of its outputs is a step-down transformer to provide a 110VAC source.

5.3 Design Preparation, Testing, and Revisions

Engineers, professors, trainers, assessors, and technicians from welding, automotive, and mechanical evaluated the welding machine. The event was held at Iloilo Science and Technology University using the established parameters: (1) resistance of the input and output winding; (2) insulation resistance of the input and output winding; (3)no load and with load primary current; (4)welding (secondary current AC); (5) engine starter (secondary current DC); (6) battery charger (Secondary current/charging current DC); (7) no load and with load primary voltage; (8)no secondary load voltage; (9) welding (secondary) voltage; (10) engine starter (secondary) voltage; (11) battery charger (secondary) voltage; (12) winding temperature; and (13) power consumption. Moreover, the 3FIM assembly was based on the standards established by the ISO and normative references, SAE and CSA C812. Figure 1 shows the design of the 3FIM.

6. Results and Discussions

6.1 Technology

6.6.1 Arc Welding

The 3FIM is a multifunctional machine that has three primary functions:

(1) an AC welding machine, engine starter for stationary engines and battery charger for storage batteries, somewhat related to the multifunction arch welding machine cited in prior art 1,2 and 3; however, it differs when it comes to its function, construction and material utilisation;

(2) although toroidal, it is known to be efficient in power consumption when used as a transformer. It also has a toroidal inductor designed to provide a fine adjustment for welding current from 45Amperes – 200Amperes, which can accommodate different sizes of electrodes applicable in various metal thicknesses to be welded. The inductor has a pilot light to serve as a contact indicator for easy adjusting current from the lowest setting to its maximum of 200 Amperes. It is further coupled by welding cable with welding cable holder and electrode holder. It has an additional feature to provide step-down voltage output from 220V to 110V, useful for electrical devices powered by 110V. Regarding its current no load on the primary side, the 3FIM only consumes 0.2A, significantly less power than other conventional welding machines. Although it is not an inverter, it is an energy saver;

(3) engine starting has a current no load of only 0.2A, voltage no load in the primary of 220VAC, frequency of 50-60hertz at 800 duty cycle. However, its output current in the secondary has a maximum of 300amperes, which is good enough to start the engine even if it is a complex starting engine. Further, the 3-F Induction machine has two primary voltage outputs needed to start the engine. It has 12VDC output and a 24VDC output controlled by a selector transfer switch. At the same time, its voltage output has a corresponding pilot light as an indicator that the machine provides the exact voltage. It also has a cable port that is appropriately labelled to identify negative and positive for its polarity easily. The cable port for the engine starter is provided by a cable holder directly attached to the machine to ensure proper storage;

(4) battery charging has a maximum secondary current output of 35amperes and can charge different storage batteries in 12VDC or 24VDC. The charging port is also provided with a proper polarity label to ensure that the correct polarity for the battery will be followed. It is also provided by a selector transfer switch to select the charging voltage, and

(5) it utilises a locally available core, a toroidal core. The single toroidal core accommodates the primary winding while the secondary winding is wound in the same core. The primary and secondary winding are correctly distributed in a single core. However, it produced three main functions: arc welding, engine starter for stationary engines, and battery charging for storage batteries. It also has an additional feature: one of its outputs is a step-down transformer to provide a 110VAC source.

6.2 Brief Description of the Drawing

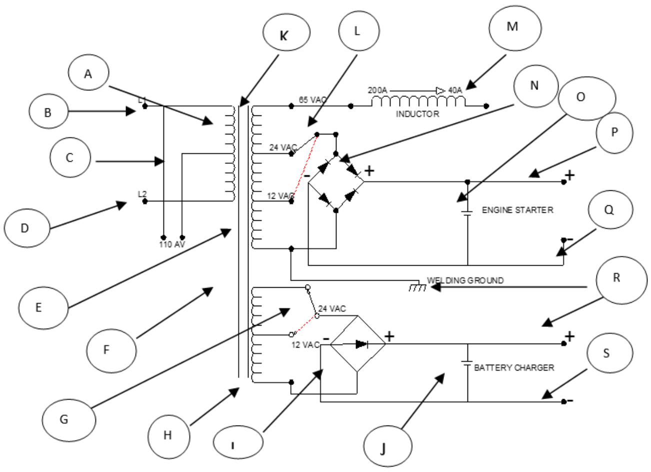

Figure 1. The 3FIMs Schematic Diagram.

6.3 Detailed Description of the Technology

The schematic diagram of 3FIM is composed of (A) primary coil, which is symmetrically arranged in (F) toroidal transformer, which will produce electromagnetic induction the moment that the supply power will be connected at (B) beginning of the primary winding and, (D) ending of the primary winding. The centre taps of the primary winding (C) and beginning (B) will produce a 110VAC output.

The secondary coil for arc welding and engine starter (K) is symmetrically arranged in a toroidal core (E) in one direction and designed to have an AC output of 65VAC, 24VAC and 12 VAC. The coil of wire (K) is connected in series to the inductor coil (M) to produce an adjustable current from 45 amperes to 200 amperes maximum for welding works, together with the ending of the coil (R) serving as welding ground. The engine starter (K) coil is connected to the selector switch (L). The common of the selector switch (L) is directly related to a bridge-type diode (N), and the ending of the coil (K) is joined to the other side of a bridge-type diode (N), which converts AC voltage to a DC voltage. To ensure that the DC voltage output is pure DC, the capacitor (O) is connected parallel across the output terminal (P) positive and (Q) negative.

The secondary coil (H) for the battery charger is separately arranged in a toroidal core (E) designed to produce 12VAC and 24VAC, wherein the beginning of the coil (H) is directly connected to the (G) selector switch. The standard selector switch is directly related to a bridge-type diode (I). The ending of the coil (H) is connected to the opposite side of the rectifier diode (I) to produce a DC voltage, and the capacitor (J) is connected across (R) positive polarity and (S) negative polarity to ensure that the output voltage is purely DC.

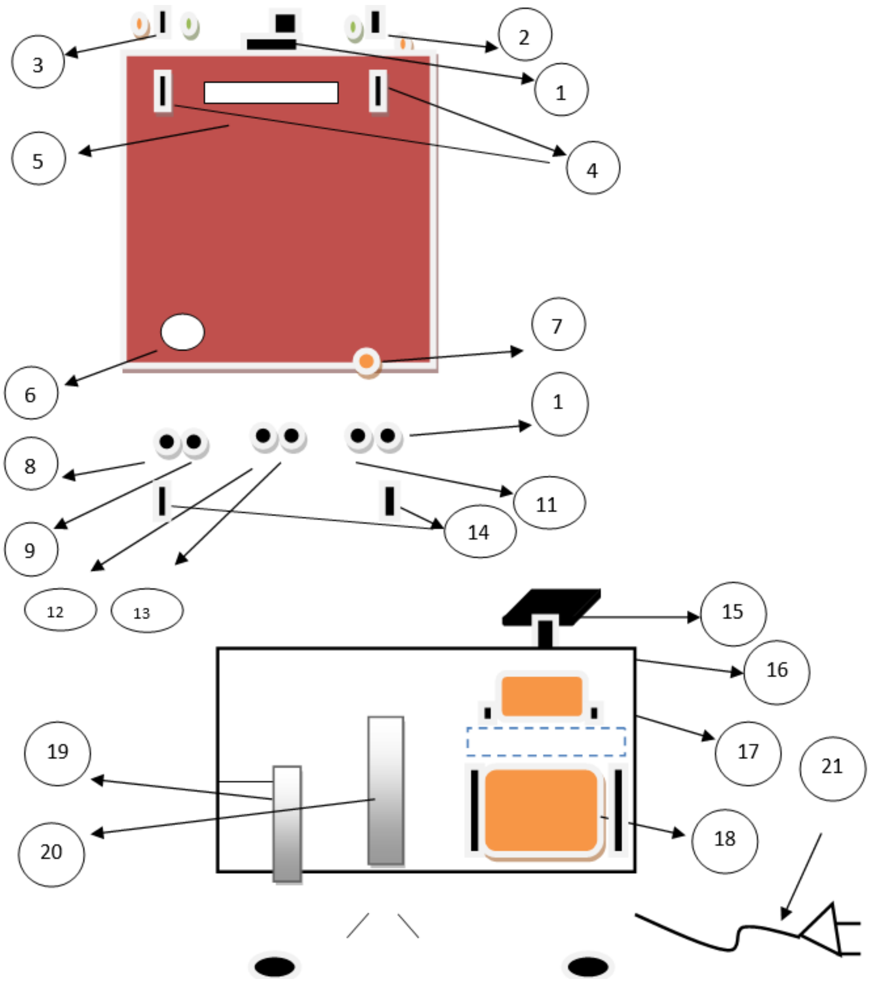

Figure 2. The 3FIM Front View and Internal Components.

The front view shows the composition of paramount circuit protection (1) with a lighting indicator which glows the moment that the supply power is being provided from the supply source (21) down to the main coil (18) composed of the primary winding and secondary winding symmetrically arranged in a single toroidal silicon core that produces electromagnetic induction. The high current toggle/transfer switch with lighting indicator (2) provides a switching mechanism for the battery charger to select 12volts dc output or 24 volts dc output depending on the needs of storage batteries recharged. Once the battery is fully charged, turn off the toggle switch (2) to the centre position. The secondary coil intended for a battery charger (18) is directly connected to the rectifier diode fastened to the heat sink (19), wherein the dc negative output of the charger will pass to (8) negative terminal result and connected directly to the negative input of battery, the DC positive output will pass in series to (6) ampere gauge or dc ammeter and (9) positive terminal outcome and directly connected to the positive input of battery. The high current toggle/transfer switch with lighting indicator (3) allows engine starters to select 12volts dc or 24volts dc output depending on the engine's capacity to be started. The secondary coil intended for the engine starter (18) is directly connected to the rectifier diode fastened to the heat sink (20). It will supply to the DC input terminal of the engine's starter. The dc negative output of the starter will pass to (12) negative terminal output, which will be directly attached to the negative terminal input of the engine's starter. The DC positive output will pass to the positive output terminal (13) after the engine has started turning the toggle switch (3) to the centre position to off the circuit. The welding current output of the machine is adjusted through the (15) handle of the welding to finely adjust the knob directly attached to the (16) shafting of the knob, which is mounted to the (17) inductor coil of the machine for welding that can be adjusted from 45amperes minimum to 200amperes maximum AC welding job. The ground wire of the secondary coil for welding (18) is directly connected to (11) welding ground terminal output. The beginning of the secondary coil winding for welding (18) is connected in series to the front of the inductor coil (17), wherein the delicate adjustment mechanism attached to shafting (16) provides welding current output, which is directly connected to (10) the welding terminal output for electrode holder. The (7) pilot light for the welding contact indicator signals to the welder if the machine is ready for welding. If the (7) pilot light glows brightly, the device is prepared for the welding operation. After the welding activity, turn off the machine using the (1) main circuit breaker and return the output terminal to its holder (4) and move the device to its designated storage place by pushing with the use of its handle (5) and ball caster (14) for easy mobility.

6.4 Interpretation of the Data

6.4.1 The Development of 3FIM as Evaluated by the Experts Regarding Resistance

Table 1: Laboratory Testing of the 3FIM in Terms of Resistance

Item	Laboratory Testing	Required/ Standard (Ohms)	Measured Data (Ohms)	Remarks
1	Resistance of the primary winding	Not higher than 100	2.2	Passed
2	Resistance of the secondary winding for the battery charger	Not higher than 100	2	Passed
3	Resistance of the secondary winding for engine booster	Not higher than 100	2.2	Passed
4	Resistance of the secondary winding for welding	Not higher than 100	2.4	Passed
5	Insulation resistance of the primary winding	100Mega	130MΩ	Passed
6	Insulation resistance of the secondary winding for battery charger, engine booster and welding	100Mega	100MΩ	Passed

Table 1 shows the overall result of the laboratory testing of the 3FIM in terms of resistance as evaluated by experts based on the given/required standard using a specific laboratory measuring instrument. Winding resistance on primary and secondary winding was tolerable based on the necessary transformer winding resistance measurement (Megger, 2020). All items were tested and passed. Resistance measuring instruments calculate and display the resistance reading without the user needing calculations. These ohmmeters measuring methods employ two-wire measuring techniques. This process means that the resistance of the two windings was safe and suitable for connecting the source of 220 VAC. Winding insulation resistance on primary and secondary winding was tolerable and passed based on the required standard of the Institute of Electrical and Electronics Engineers (IEEE) (2020). Based on the findings of this study, it is implied that the 3FIM has excellent windings resistance that reduces electric current flowing in the machine when used to a 220 voltage source. Further, the insulation resistance between the primary and secondary windings and the ground frame is safe from the leakage current. Proper insulation was being implemented to meet the machine requirement.

6.4.2 3FIM as Evaluated by the Experts Regarding Current

Table 2: Overall Result of the Laboratory Testing of the 3FIM in Regarding Current

Item	Laboratory Testing	Required/Standard (Amperes)	Measured Data (Amperes)	Remarks
1.	No-load current primary	0.01-5	0.2	Passed
2.	With primary load current for welding	60	18-40	Passed
3.	With primary load current for engine	15-30	10-20	Passed

	starter			
4.	With primary load current for a battery charger	5-15	5-10	Passed
5.	Welding (secondary Current AC)	5-500	45-200	Passed
6.	Engine starter (secondary current DC) (12VDC)	180-300	180-250	Passed
7.	Engine starter (secondary current DC) (24VDC)	180-300	180-300	Passed
8.	Battery charger (secondary current/charging current DC) (12VDC)	30-45	5-35	Passed
9.	Battery charger (secondary current/charging DC) (24VDC)	30-45	10-35	Passed

Table 2 shows the 3FIM expert's evaluation concerning current as tested using a clamp-on ammeter. All items passed the welding, engine starting, and charging requirements standards. This result means that the device performs well compared to the market.

6.4.3 The 3FIM as Evaluated by the Experts Regarding Voltage

Table 3: Overall Result of the Laboratory Testing of the 3FIM Regarding voltage

Item	Laboratory Testing	Required/ Standard (Volts)	Measured Data	Remarks
1.	No-load primary voltage	200 -250	220VAC	Passed
2.	No secondary load voltage for welding	24-80	65VAC	Passed
3.	No secondary load voltage for engine starter	12 -24	12-24VDC	Passed
4.	No-load secondary voltage for the battery charger	12 -24	12- 24VDC	Passed
5	With secondary load voltage for welding	24-80	65VAC	Passed
6	With secondary load voltage for engine starter	12 -24	12 – 24VDC	Passed
7	With secondary load voltage for the battery charger	12 -24	12 – 24VDC	Passed

Table 3 shows the 3FIM expert's evaluation concerning voltage conformed to the industry's standards and got a passing grade. Specifically, the required load in welding, starting a stationary engine, and charging a battery passed the testing. Hence, the machine is efficient, effective, and safe to use.

6.4.4 The 3FIM as Evaluated by the Experts Concerning Temperature

Table 4: Overall result of the laboratory testing of the 3FIM Regarding temperature

Item	Laboratory testing	Required/Standard	Measured Data	Remarks
1.	Winding temperature (primary winding)	60^0C to70^0C	47^0C	Passed
2.	Winding temperature (secondary winding)	60^0C to70^0C	50^0C	Passed
3.	Regulator winding temperature	60^0C to70^0C	65^0C	Passed

Table 4 shows that the 3FIM expert's evaluation concerning temperature conformed to the industry's standards and got a passing grade. Specifically, the required load in welding, starting a stationary engine, and charging a battery passed the testing. Therefore, the machine's materials are designed to meet the industry's standard due to its durability, although locally-made device. Below is the sample computation of power consumption, to wit:

- The power consumption of 3FIM was evaluated through simple electrical formula. P=VXI; where; P- power, V-voltage, I-current.
- The machine was tested as an arc welding machine in 15 minutes with the maximum primary current with a load of 40 amperes at 220volts ac. Using the formula P= VxI, P = 220 x 40 = 8,800 watts, the unit of power consumed is measured in kilowatts. Therefore 8,800÷1,000 =8.8KW at 15 minutes, that is 25 per cent of 1hour, so (8,800) (.25) = 2,200 or 2.2KW, the power consumed by the machine is only 2.2KW at 15minute of use.
- However, it takes less energy to maintain the magnetic field in a toroidal core. It is known as excitation or quiescent power. Toroids require about 1/16 of the excitation power of conventional transformers is translated into significant savings in large transformer applications such as industrial controls.
- Considering the 1/16 power saving of a toroid transformer, the computed power consumption of the machine as used in welding for 15 minutes is; (2,200) (1/16) =137.612,200 -137.61= 2,062.39 Watts or equivalent to 2.06239KW.
- When used as an engine starter, the power consumption of the 3-F Induction Machine was evaluated using the same formula used in the welding machine computation. Wherein the primary current with load maximum is 30 amperes with a primary voltage of 220 volts by applying the same formula, the power will be; P = E x I, P = 220 x 30 = 6,600watts, since that the unit of power consumed is measured in kilowatt. Therefore 6,600÷1,000 =6.6KW at 15 minutes that is 25 per cent of 1hour so (6,600) (.25) = 1,650 or 1.650KW, the power being consumed by the machine is only 1.650KW at 15minute of use.
- Considering the 1/16 power saving of a toroid transformer stated above, the computed power consumption of the machine as used in engine starter for 15 minutes is; (1,650) (1/16) =103.125, therefore1,650 -103.125= 1,546.875Watts or equivalent to 1.546,875KW.
- When used as a battery charger, the power consumption of the 3-F Induction Machine was evaluated using the same formula used in the welding machine and engine starter

computation. Wherein the primary current with load maximum is 10 amperes with a primary voltage of 220 volts; by applying the same formula, the power will be; P = E x I, P = 220 x 10 = 2,200watts, since that the unit of energy consumed is measured in kilowatt; therefore 2,200÷1,000 =2.2KW at 15 minutes that is 25 per cent of 1hour so (2,200) (.25) = 550 or .55KW, the power being consumed by the machine is only .55KW at 15minute of use.

- Considering the 1/16 power saving of a toroid transformer stated previously, the computed power consumption of the machine as used in battery charger for 15 minutes is; (550) (1/16) =34.375, therefore550 -34.375= 515.625Watts or equivalent to 0.515625KW.
- The study's findings implied that in terms of power consumption, the 3FIM is more energy-efficient than a domestic welding machine, which already consumes 3-5amperes current no load. In contrast, the device only requires 0.2 amperes primary current and no load.

7. Findings

The construction of 3FIM conformed to its design using locally available supplies and materials. The machine can be used efficiently as an arc welding machine, engine starter for stationary engines, and battery charger for storage batteries. All parameters covering the three functions of the machine were tested and evaluated by a group of technical experts. Based on a thorough evaluation, it was found that the operating performance of the 3FIM as assessed by experts in terms of the resistance of the input and output winding implied that the machine has excellent windings resistance that reduces electric current flowing in the machine when used to 220 voltage source. Moreover, the 3FIM has insulation resistance between the primary and secondary windings, and the ground frame is safe for the leakage current. Further, proper insulation was being implemented to meet the machine requirement. Hence, the following were the findings:

- The expert’s evaluation and assessment of 3FIM on no-load conform regarding the primary and secondary current was passed according to the industry's standards.
- The expert's evaluation of 3FIM performance conforms to no-load, and with load, the primary and secondary voltage is passed according to the standard and evaluated by the experts.
- The expert's evaluation of 3FIM conforms to winding temperature conforms in terms of the temperature check test passed according to the industry standard.
- In terms of power consumption, the expert's evaluation of 3FIM is more energy-efficient than a domestic welding machine, which already consumes 3-5amperes current no-load. Hence, the device only requires 0.2 amperes primary current and no load.

8. Conclusions

The design and construction of 3FIM suit its purpose as an arc welding machine for a stationary engine starter and a battery charger.

- The 3FIM can operate in 15 minutes of continuous duty with less energy consumption than an arc welding machine. Moreover, it is more efficient because the circulating Current or current no load is just 0.2 ampere, which is already a significant advantage compared to the conventional machine. The welding current can be easily adjusted based on the needs of the welding job because of its accurate current regulator. Further, all required parameters conformed to the standard during the laboratory testing and were evaluated by experts.
- As to the operating performance of the 3FIM, when used as an engine starter, it can operate in standard continuous duty with less energy consumption due to a shallow circulating current. The machine provides dual voltage output of 12 volts and 24 volts DC with a transfer switch for ease of usage. All required data for engine starter requirements was attained during the laboratory testing and evaluated by experts.
- As to the operating performance of the 3FIM when used as a battery charger, it can operate normally in continuous usage with less energy consumption but is efficient to use. The machine has dual charging output provided by a transfer switch for operator safety and ease of charging. It can draw 12 and 24 volts DC, and all the required data for battery charger requirements was attained during the laboratory testing and evaluated by experts as passed.
- Generally, the 3FIM has conformed to its purpose as a welding machine, engine starter, and battery charger. It takes less energy to maintain the magnetic field in a toroidal core. In addition, the device has less energy consumption. Moreover, the circulating current or the primary current no load is 0.2 ampere makes this very advantageous compared to other machines. This result is known as excitation or quiescent powerhttps://www.plitron.com/ or significant savings in large transformer applications such as industrial controls.

Recommendations

- For further improvement of the study, the researcher considered the recommendations below. Some suggestions were the insights imparted by the evaluators.
- The 3FIM is beneficial to industry workers and shop owners. This result can help to reduce energy consumption compared to conventional welding machines. Further, it can also avoid acquiring costly devices which can be used only for one purpose. In contrast, the 3FIM can already be used as a welding machine, engine starter, and battery charger.
- Some experts suggested that, if possible, reproduce the machine and further refine its design into a lighter weight for ease of transportation. Change the improvised transfer switch of the battery charger and engine starter to a toggle high current switch for easier usage.
- In addition, provide an auxiliary fan as a standby cooling system in case the temperature of the machine increases beyond its limit design. Subject the device for patenting to preserve the structure and introduce it to the market.

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